REMARKS/ARGUMENTS

The specification has been revised as requested on pages 2 and 3 of the Office Action to conform it to the preferred format and now includes subheadings. A Substitute Specification and Comparison Copy are submitted herewith.

Claims 2, 4-12, 14-16 and 26-30 are presently pending in this application. Claims 1, 3, 13 and 17-25 have been canceled.

The original claims were rejected under Section 112 because of their use of the terms "or", "and/or", "preferably" and "in particular". These terms have been deleted in favor of corresponding wording, such as "without at least one of …", for purposes of clarification unrelated to patentability concerns.

All new claims are in full compliance with Section 112.

Accordingly, applicants request retraction of the Section 112 rejection.

All claims were rejected for anticipation by either Sorimachi (4,867,570) or Ogawa (5,512,997) or for obviousness (pending claims 14-19 and 24) over Sorimachi when combined with Takada (EP-0540343 B1).

Sorimachi was viewed as anticipating originally filed claims 1-9, 12-13, 20-23 and 25 because it discloses a distance measuring device using triangulation and employing at least one measuring channel and at least one additional channel which has a further transmission unit and reception unit.

Original claims 1-9, 12-13, 17, 20-23 and 25 were rejected because Ogawa was viewed as disclosing a distance measuring device with at least one measuring channel and at least one additional channel with further transmission and reception units.

Original claims 10-11, 14-19 and 24 were rejected over Sorimachi and Takada because focusing the two channels at different distances, which is not taught by Sorimachi, was considered taught by Takada, which has two channels focused at different distances.

Reconsideration and retraction of the rejection in view of the following is requested.

New independent method claim 26 is effectively a combination of original claims 1 and 13. New apparatus independent claim 30 is directed to the same aspect of the invention as claim 26 but expresses it in apparatus terminology. Both claims are directed to the features of the present invention shown in Figs. 3a, b, which uses two channels, S1-E (measuring channel) and S2-E (additional channel). The light beam of the additional channel is spatially expanded in comparison to the sensing zone of the measuring channel. The position X1 of Fig. 3b corresponds to the object distance D which is to be determined. Position X2 corresponds to the distance of the interfering object 15. The intensity peak of the transmission unit S2 of the additional channel at position X2 is higher than that of the measuring channel as a result of the expansion of the sensing zone, and thus does not represent the object distance D that is to be determined.

Expansion of the light beam of the additional channel is attained by non-focusing, scattering, expansion and/or diffusion of the beam. With respect to Fig. 3b, the specification discloses:

> … radiation transmitted in the measuring channel S1-E is also incident on the interfering object 15 and is reflected and/or remitted by this onto the reception unit E, whereby an intensity peak is generated at the position X2. The corresponding intensity peak of the transmission unit S2 of the additional channel is higher than that of the measuring channel in which the operation takes place with focused sensing rays 25 as a result of the deliberate imaging of the interfering radiation. At the position X1, however, which corresponds to the object distance D to be determined, a higher received signal occurs in the measuring channel S1-E than in the additional channel S2-E, since the intensity distribution of the sensing zone at the sensed object is lower than that of the sensing rays 25 with which a sensing spot is generated on the sensed object 13.
>
> The joint evaluation of the received signals of the two channels takes place in that the received signal S2 of the additional channel

> is deducted from the received signal S1 of the measuring channel... (original specification, page 15, lines 7-26)

Original claims 1 and 13 were rejected for anticipation by Sorimachi.

Sorimachi does not disclose or in any form suggest to widen one of the light beams passing through the windows in mask plate 3. Sorimachi is directed to three-dimensionally processing data for obtaining information associated with a three-dimensional shape. Aside from not disclosing to widen any of its light beams, widening the beams for purposes of three-dimensional information processing is disadvantageous because it would result in blurred optical images on the image sensor, and the resulting distance measurement range would be severely limited thereby. Sorimachi therefore does not anticipate claim 26.

Claims 1 and 13 were also rejected for anticipation by Ogawa, which discloses the use of a light emitting diode 13 which generates infrared light that is <u>converged</u> by a projection lens 14 and directed onto a subject. In this regard, Ogawa states:

> A control circuit 11 drives an infrared LED driver 12, so that an infrared light-emitting diode 13 generates an infrared light, which is <u>converged</u> by a projection lens 14 and shone onto a subject A. (column 2, lines 21-24, emphasis added)

While claims 26 and 30 recite "<u>expanding</u> the second sensing rays ...", Ogawa discloses the opposite, namely converging the light. Thus, Ogawa cannot and does not anticipate claims 26 and/or 30.

New independent claim 27 submitted herewith is directed to the invention as best illustrated in Figs. 1a, 1b and 2a, 2b.

As shown in Figs. 1a, b, two transmission units S1 and S2 cooperate with reception unit E so that each transmission unit generates a received signal on reception unit E. The distance $a \cdot \Delta X$ of the two received signals is proportional to the distance ΔX of the two transmission units and is independent of the object distance D. An undesired interference signal which also generates a received signal but which is not displaced by the expected amount $a \cdot \Delta X$ to one of the two other received signals can be identified as such.

Fig. 1b illustrates the separation of the interference signal from the wanted signal. In this regard, the application states:

> However, by the provision, in accordance with the invention, of an additional channel, which is realized in the present embodiment by provision of an additional transmission unit S2, the interference signal can be identified as such. For this purpose, use is made of the fact that the distance $a \cdot \Delta X$ of the two received signals on the reception unit E is proportional to the distance ΔX of the two transmission units S1, S2, in the corresponding direction. …. This relationship applies to all object distances D, that is the correlation between ΔX, on the one hand, and $a \cdot \Delta X$, on the other hand, is independent of the object distance D.
>
> In the joint evaluation in accordance with the invention of the received signals of the measuring channel S1-E and of the additional channel S2-E, characteristic regions of the intensity curves in the form of peaks, which could correspond to a sensing spot reflected and/or remitted by the sensed object 13, are examined as to whether they are mutually displaced by the expected amount $a \cdot \Delta X$. If this is not the case, then these characteristic ranges are eliminated from the determination of the distance ….
>
> If it is found, in contrast, that two peaks of the intensity distributions are mutually displaced by the expected amount of $a \cdot \Delta X$, then at least one of these peaks is used to determine the object distance D, with the position of its center X1 or X2 representing a measure for the object distance D. (page 11, line 26 to page 12, line 24 of the original specification)

Alternatively, and as Figs. 2a, b illustrate, the relative sharpness of the images received by the reception unit E is checked as the additional criterion. In this regard, the specification states:

> If the sensed object is located relatively close to the sensor 11, then the sensing spot of the one transmission unit is imaged more sharply on the receiver than that of the other transmission unit, with the difference in sharpness being able to be detected by the different widths of the mutually corresponding regions or peaks of the respective intensity distribution A or B. ….

> If interfering radiation, for example due to a reflecting interfering object 15 (cf. Fig. 2a) is incident on the reception unit, then the intensity distribution C shown schematically in the lower illustration of Fig. 2b results, for example. The interference signal of the interfering object 15 can therefore have the consequence that it can no longer be assumed, on the basis of a difference in the sharpness of the imaged sensing sports [sic] corresponding to an expected amount, that the peaks can be used to determine the correct object distance.
>
> The presence of an interfering object 15 adulterating the measurement can therefore be recognized by the detection of a received signal not showing the expected intensity curve.

Claim 27 is effectively a combination of original claims 1 and 3, which were rejected for anticipation by Sorimachi and Ogawa.

Sorimachi discloses to obtain three-dimensional information about an object. Using a mask plate 3 with a plurality of rectangular slitted windows Wn (see Fig. 2 of Sorimachi), a <u>plurality of distances</u> Fn to an object 6 are measured. Although any two windows of the mask plate could be considered to correspond to the two channels of the present invention, any second channel used by Sorimachi determines <u>its own distance</u> to the object 6 and <u>is not used</u> to determine whether the received signals fulfill at least one additional criterion.

Claim 27 specifically recites "determining from the signals received by the further reception unit whether the signals fulfill at least one additional criterion; and using the distance value as the measure of the object distance if the additional criterion is fulfilled". As discussed above, each "channel" of Sorimachi determines its own distance, and no attempt is made to determine an additional criterion. Accordingly, Sorimachi does not anticipate claim 27.

Ogawa, over which claims 1 and 3 were also rejected for anticipation, discloses to measure the distance of an object. By using first and second line sensors arranged in parallel to one another and offset from each other in their longitudinal direction by a predetermined amount, Ogawa doubles the resolution of the distance measurement (Figs. 1 and 2). As in Sorimachi, both channels of Ogawa are used and have to be used to determine one common distance value.

No channel of Ogawa is used to determine whether or not an additional criterion has been fulfilled, as is recited in new claim 27. Thus, Ogawa does not anticipate claim 27.

New independent claim 28 is effectively a combination of original claims 1, 17 and 18 and is directed to the feature of the present invention which arranges the transmission unit between the two reception units.

New independent claim 29 is effectively a combination of original claims 1, 17 and 19 and is directed to placing the two reception units on the same side as the transmission unit, as is illustrated in Figs. 4a, b.

If only one reception unit and thus only one received signal were present, the intensity distribution of the received signals would be adversely affected because it would be shifted in the direction of the region having a high reflectance or remittance capability.

With the additional channel as recited in claims 28 and 29, including the further reception unit E2, an additional signal is received which is affected by contrast edge 17 of the object. As a result, two received signals are available which each have a characteristic region caused by the contrast edge in which the intensity changes abruptly, or stepwise, as is illustrated in Fig. 4b.

The specification states in regards to this feature of the present invention:

> In the evaluation of the intensity distributions, these characteristic regions can be identified without problem and associated with corresponding positions X1, X2 on the reception units E1, E2. Independently of the specific curve of the intensity distributions of the received signals, the distance ΔX of the positions X1, X2 of the characteristic regions forms a measure for the object distance D to be determined. (original specification, page 17, lines 19-25)

Original claim 18, which has been combined with claim 1, and is being submitted as new independent claim 28, has been rejected for obviousness over Sorimachi in view of Takada.

Claim 28 recites, amongst others, "respectively determining for the received signals a center of an intensity distribution of the detected sensing rays coming from the measuring region and a distance of the center from a position of the transmission unit, and using a mean value of the center distances as a measure for the object distance". Neither Sorimachi nor Takada disclose or in any form suggest this aspect of claim 28.

Takada discloses an optical measurement system for determining the depth D of a step in a profile of an object by using two optical heads 10, 20 (see Fig. 1) which direct individual light beams to different points on the object's surface for measuring distances D1, D2 of these points from a reference plane by triangulation, where D = D1 - D2. Thus, in Takada each of the received signals is also converted into a distance, and the depth D is obtained by the difference of two distances.

In contrast to Sorimachi and Takada, new independent claim 28 requires that the "mean value of the ccnter distances" be determined, which is neither disclosed or in any form suggested by thc two referenccs taken singly or in combination.

New independent claim 29 is effectively a combination of claims 1, 17 and 19. It requires that the two reception units and/or optical reception systems are arranged at the same side of the transmission unit. The distance ΔX between two corresponding characteristic regions of the received signals of the measuring and additional channels is used as a measure of the object distance D.

Original claims 1 and 19 were rejected for obviousness over Sorimachi and Takada. Neither of the two references suggest this feature.

Claim 29 recites "using a distance between mutually corresponding characteristic regions of the received signals of the first and second channels as a measure for the object distance". In contrast, in both Sorimachi and Takada <u>each of the received signals</u> is converted into a distance, and the depth D is obtained by the difference of two distances. Thus, Sorimachi and Takada, taken individually or in combination, do not suggest the recited claim limitation.

In view of the foregoing, applicants submit that Sorimachi and Ogawa do not anticipate new independent claims 26 and 27, and the combination of Sorimachi and Takada does not suggest new independent claims 28 and 29. Accordingly, independent claims 26-29 are neither anticipated by nor obvious in view of the applied references for the reasons discussed in detail above.

Dependent claims 2, 4-12 and 14-16 are directed to specific features of the present invention which are neither disclosed nor suggested by the applied references. These claims are therefore patentable in their own right, and they are further allowable because they depend from allowable parent claims.

CONCLUSION

In view of the foregoing, this application is now in condition for allowance, and a formal notification thereof at an early date is requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 415-576-0200.

Respectfully submitted,

J. Georg Seka
Reg. No. 24,491

TOWNSEND and TOWNSEND and CREW LLP
Two Embarcadero Center, 8th Floor
San Francisco, California 94111-3834
Tel: (415) 576-0200
Fax: (415) 576-0300
JGS:jhw
60033989 v1

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~~Sick AG~~ 9Attorney Docket No. 86523
Client No. S 7961

~~**Distance determination**~~

SUBSTITUTE SPECIFICATION

DISTANCE DETERMINATION

Background of the Invention

[0001] The invention relates to a method and to an apparatus for determining the object distance between an opto-electronic sensor working according to the principle of triangulation and a sensed object.

[0002] With known sensors which work according to the principle of triangulation, an emitted light spot is imaged on the object whose distance is to be determined and from the object onto a spatially resolving receiver. The position of the reflected and/or remitted light spot on the receiver is dependent on the distance between the sensor and the object, also known as the operating distance. The position of the center of the light spot on the receiver can thus be used as a measure for the distance to be determined. It is known for this purpose to divide the light-sensitive range of the receiver into two sub-ranges, namely a near range and a far range. The distribution of the intensity of the imaged light spot between the near range and the far range is dependent on the object distance so that the difference between the output signals of the two ranges forms the measure for the object distance.

[0003] The disadvantage with these sensors is that interference signals superimposed on the actual received signal which comes from the light spot reflected and/or remitted by the object cannot be recognized as such. Sources of such interference signals are, for example, defects in or

contaminations of the sensor optical system, reflecting or shiny areas or areas of high contrast either on the object whose distance is to be determined or on interfering objects arranged to the side or the rear of the object to be sensed and which are also known as background objects.

Summary of the Invention

[0004] It is ~~the~~an object of the invention ~~to provide a possibility~~ to determine the distance between the sensor and an object in the simplest and most reliable manner possible using an opto-electronic sensor working according to the principle of triangulation independently of any error sources which may be present and which adulterate the actual received signal.

[0005] This object is satisfied, on the one hand, ~~by the features of method claim 1 and in particular~~ in that the sensor has at least one measuring channel between a transmission unit for the transmitting of electromagnetic sensing rays into the measuring region and a reception unit for the detection of sensing rays reflected and/or remitted from the measuring region, in that the sensor has at least one additional channel having a further transmission unit and/or a further reception unit in addition to the transmission unit and the reception unit of the measuring channel, and in that the received signals of the measuring channel and of the additional channel are jointly evaluated in order to determine the object distance.

[0006] In accordance with the invention, additional information is made available by the additional channel and can be used, by the joint evaluation ~~with~~of the information from the measuring channel, in order to identify error sources as such and so to reduce the influence of the error sources on the distance measurement.

[0007] The joint evaluation takes place in an evaluation unit which is associated with the sensor and to which the reception unit or reception units are connected. Suitable mathematical evaluation methods, for example cross-correlations between a stored or learned intensity distribution of the received signals and a current intensity distribution, can be used respectively in dependence on the design of the method for the distance measurement or on the design and the mode of operation of the sensor.

[0008] It is preferred for the measuring channel and the additional channel to be operated jointly and in particular at least substantially simultaneously for each object distance.

[0009] This also includes the case where the channels are successively controlled in fast succession by, for example, a plurality of transmission units successively emitting their sensing rays in short time intervals and/or a plurality of reception units being successively read out in order to determine the respective object distance by a joint evaluation of the received signals.

[0010] In accordance with an embodiment of the invention, provision can be made that only the received signal of the measuring channel is used for the determination of a distance value, that a determination is made by means of the received signal of the additional channel whether the received signals meet at least one criterion and that, if the additional criterion is met, the distance value is used as a measure for the object distance.

[0011] Only the received signal of the measuring channel is thus used for the actual distance measurement after a check has been made with the aid of the received signal of the additional channel whether the measurement satisfies certain demands and the received signals meet

certain additional conditions. A decision can thus be ~~taken~~made by means of the additional channel whether the received signal of the measuring channel has been adulterated or not.

[0012] In accordance with an alternative embodiment of the invention, it can be provided that the received signals of both the measuring channel and the additional channel are used to determine a distance value serving as a measurement for the object distance.

[0013] In this respect, the distance value is not only determined with the aid of one of the received signals, but the received signals of both the measuring channel and the additional channel are used for the determination of the object distance.

[0014] It is preferred ~~for~~that the respective intensity distribution of the received signal on the reception unit or on the reception units ~~to~~ be used for the distance determination in the measuring channel and/or in the additional channel.

[0015] In accordance with another aspect of the invention, spatially resolving detectors of generally any desired kind can be provided as reception units. The position of a light spot or bead reflected and/or remitted from the object and information on the circumstances of the light spot reflection and/or remittance can be read off from the detected intensity distributions.

[0016] In a preferred embodiment of the invention, a separate transmission unit and preferably a common reception unit are respectively used for the measuring channel and the additional channel.

[0017] In this variant of the invention, work is carried out with at least two reception units which are operated such that the emitted sensing rays are incident at different positions on the object so that a corresponding positional difference is detected on the reception unit.

[0018] In this respect, the two transmission units can emit the sensing rays in different directions for the formation of the measuring channel and of the additional channel. Then mutually corresponding characteristic ranges of the reception signals of the measuring channel and of the additional channel are each examined, preferably in the joint evaluation, as to whether they are in particular mutually displaced by an expected amount.

[0019] Provision is alternatively made, in accordance with a further embodiment of thc invention, when a plurality of transmission units are used, that the sensing rays of the measuring channel and of the additional channel are focused at different distances, with preferably a near range being focused at in one channel and a far range being focused at in the other channel.

[0020] Then mutually corresponding characteristic ranges of the received signals of the measuring channel and of the additional channel are preferably respectively examined in the joint evaluation as to whether the emitted sensing rays are imaged in particular with different sharpness, in particular different sharpness in accordance with an expected amount.

[0021] In a further alternative in accordance with a further embodiment of the invention using a plurality of transmission units, it is provided that the sensing rays of the additional channel are deliberately emitted, in particular in an unfocused, scattered, expanded and/or diffuse

manner, such that a spatially expanded sensing zone is emitted into the measuring region. In this respect, the sensing zone can preferably cover a substantial part of the half-space of the sensor on the sensed object side or at least substantially the whole half-space.

[0022] Then, in the joint evaluation, a difference is preferably formed between the received signals of the measuring channel and of the additional channel. In this respect, first the received signal of the additional channel is preferably deducted from the received signal of the measuring channel, negative difference values are subsequently set to zero and a resulting positive difference signal is then used for the determination of the distance.

[0023] The scattered light resulting in interference signals can be imaged by the spatially expanded sensing zone so that critical viewing regions of the sensor can be monitored for the presence of interfering objects or ~~artefacts~~artifacts.

[0024] In accordance with the invention, not only a plurality of transmission units can be provided, but alternatively a division into a plurality of reception units and/or optical reception systems can also be made on the reception side, with a joint transmission unit preferably being used for the measuring channel and the additional channel.

[0025] In accordance with a preferred variant of the invention, the transmission unit is in this respect arranged between the at least two reception units and/or optical reception systems, a center and the distance of the center from the position of the transmission unit are respectively determined for the received signals and the mean value of the center distances is used as the measure for the object distance.

[0026] In accordance with an alternative variant of the invention, the at least two reception units and/or optical reception systems are arranged at the same side of the transmission unit and the distance between mutually corresponding ranges of the received signals of the measuring channel and of the additional channel are used as the measure for the object distance.

~~Whereas the employment of~~[0027] While a plurality of transmission units can ~~in particular~~ be used when reflecting or shiny interfering objects are to be expected next to or behind the object to be sensed, a plurality of reception units and/or optical reception systems are ~~in particular~~ used when errors can be expected as a result of a relatively high -contrast sensed object.

[0028] All variants of the invention ~~mentioned in the claims~~, the introduction to the description and the following description of the Figures can also be combined with one another – provided that they do not contradict one another – whereby a particularly secure and reliable determination of the object distance is possible.

[0029] The underlying object of the invention is satisfied, on the other hand, by ~~the features of apparatus claim 20 and in particular by~~ an apparatus for the determination of the object distance between an optoelectronic sensor working according to the principle of triangulation and a sensed object having at least one measuring channel between a transmission unit for the transmission of electromagnetic sensing rays into the measuring region and a reception unit for the detection of sensing rays reflected and/or remitted from the measuring region, having at least one additional channel which has a further transmission unit and/or a further reception unit in addition to the transmission unit and the reception unit of the measuring channel and having an evaluation unit for the joint

evaluation of the received signals of the measuring channel and of the additional channel for the determination of the object distance.

[0030] All transmission units and reception units are preferably arranged in a common sensor plane which preferably extends perpendicular to the distance direction which corresponds to the shortest distance between the sensor and the object and which is also termed the transmission and/or reception axis.

[0031] The or each transmission unit is preferably provided in the form of an LED or of a laser device, for example a laser diode. Furthermore, the or each reception unit is preferably provided in the form of a spatially resolving detector, for example in the form of a single -row or multi-row photodiode array, of a CCD (charge coupled device) or of a PSD (position sensitive device).

[0032] Further embodiments of the invention are also set forth in the ~~dependent claims, the~~ description and the drawing.

[0033] The invention will be described in the following by way of example with reference to the drawing. ~~There are shown:~~

Brief Description of the Drawings

[0034] Figs. 1 – 4 -4 show different embodiments of the invention ~~in each case in schematic representations, and indeed respectively showing~~which employ a sensor arrangement (Figs. 1a, 2a, 3a, 4a) and intensity distributions on the reception side (Figs. 1b, 2b, 3b, 4b).

Description of the Preferred Embodiments

[0035] In the embodiment of the invention in accordance with Figs. 1a and 1b, the sensor 11 comprises two spatially separate transmission units

S1 and S2 spaced in a sensor plane 21 by ΔX and, for example, each in the form of an LED or a laser diode. A common optical transmission system FS is associated with the transmission units S1 and S2, for example in the form of a lens for the focusing of the sensing rays.

[0036] Furthermore, the sensor 11 has a joint reception unit E for the two transmission units S1, S2, for example in the form of a single-row or multi-row photodiode array, which is likewise arranged in the sensor plane 21. The reception unit E is associated with an optical reception system FE formed, for example, as a lens. Alternatively, the reception unit E could also be arranged outside the sensor plane 21.

[0037] The ~~said~~ sensor components are arranged in a common sensor housing 23 which is indicated by a chain-dotted line in Fig. 1a.

[0038] The sensor 11 serves to determine the distance D, termed the object distance in the following, between the sensor 11 and a sensed object 13 lying in the measuring range region of the sensor 11. The sensor plane 21, for example, as is indicated in Fig. 1a, serves as the reference plane for the determination of the distance.

[0039] The sensor 11 operates according to the principle of triangulation. Sensing rays emitted by the transmission units S1, S2 are reflected and/or remitted by the sensed object 13 after passing through the optical transmission system FS and are imaged on the common reception unit E by means of the optical reception system FE. Each transmission unit S1, S2 generates a light spot or a sensing spot 19 on the sensed object 13, with said sensing spot 19 being imaged on the reception unit E and its position on the reception units E being dependent on the object distance D.

[0040] If no interference sources are present, then the object distance D can already be determined from the position of a sensing spot on the reception unit E.

[0041] The provision in accordance with the invention of two separate, jointly operated channels, that is of a measuring channel S1-E and an additional channel S2-E, allows a secure and reliable measurement of the object distance D even when interference sources are present which reflect and/or remit the radiation emitted by the transmission units S1, S2 to the reception unit E and thus adulterate the actual received signals coming from the sensed object 13. The interfering objects can, for example, be surfaces with a high reflection and/or remittance capability, in particular reflecting surfaces, next to or behind the sensed object 13. Such a reflecting interfering object 15, which is located outside the transmission axis, is represented schematically in Fig. 1a.

[0042] The influence of the interfering object 15 and the procedure in accordance with the invention to separate the interference signal from the wanted signals are indicated in Fig. 1b.

[0043] Fig. 1b shows the distribution of the intensity I of the radiation of wanted signals reflected and/or remitted overall onto the reception unit E in a direction X. The intensity distribution of the transmission unit S1 is indicated by a solid line, that of the transmission unit S2 by a broken line. Each intensity distribution has two characteristic regions, namely a represented wanted signal with a center at X1 or X2 which corresponds to the sensing spot 19 reflected and/or remitted by the sensed object 13 and an interference signal which is not represented. The interference signals have a center at the same position on the reception unit E with reference to both transmission units S1 and S2.

[0044] Only the positions X1 and X2 form a measure for the correct object distance D. The evaluation of the position of the center of the interference signals would result in an incorrect object distance. If only a single measuring channel were to be present and thus only a single intensity curve were to be available, then there would be a risk – without the additional information – of the sensor 11 assessing the interference signal as a wanted signal and providing an incorrect distance value by the evaluation of the position of the ~~centre~~center of the interference signals.

[0045] However, by the provision, in accordance with the invention, of an additional channel, which is realized in the present embodiment by provision of an additional transmission unit S2, the interference signal can be identified as such. For this purpose, use is made of the fact that the distance $a \cdot \Delta X$ of the two received signals on the reception unit E is proportional to the distance ΔX of the two transmission units S1, S2, in the corresponding direction. The proportionality factor a is dependent on the imaging properties of the optical transmission system FS and the optical reception system FE, that is $a = f$ (FS, FE) applies. This relationship applies to all object distances D, that is the correlation between ΔX, on the one hand, and $a \cdot \Delta X$, on the other hand, is independent of the object distance D.

[0046] In the joint evaluation in accordance with the invention of the received signals of the measuring channel S1-E and of the additional channel S2-E, characteristic regions of the intensity curves in the form of peaks, which could correspond to a sensing spot reflected and/or remitted by the sensed object 13, are examined as to whether they are mutually displaced by the expected amount $a \cdot \Delta X$. If this is not the case, then these characteristic ranges are eliminated from the determination of the distance

and either an error message is produced or further characteristic regions of the intensity distributions are examined.

[0047] If it is found, in contrast, that two peaks of the intensity distributions are mutually displaced by the expected amount of $a \cdot \Delta X$, then at least one of these peaks is used to determine the object distance D, with the position of its center X1 or X2 representing a measure for the object distance D.

[0048] In the embodiment of the invention illustrated in Figs. 2a and 2b, the sensor 11 is in turn provided with two separate transmission units S1 and S2 with which a common reception unit (not shown) is associated. In this embodiment, each transmission unit S1, S2 is associated with a separate optical transmission system FS1, FS2 in the form, for example, of a lens.

[0049] The optical transmission systems FS1 and FS2 differ in that they focus the sensing rays emitted by the transmission units S1 and S2 at different distances d1 and d2 respectively. Depending on the distance to be determined of a sensed object not shown in Fig. 2a from the sensor 11, the sensing spot of the one transmission unit S1 is thus imaged more sharply or less sharply on the reception unit than the sensing spot of the other transmission unit S2.

[0050] The expected intensity distribution of the wanted signals basically corresponds to the distributions A, B which are shown schematically in the upper illustration of Fig. 2b. If the sensed object is located relatively close to thc sensor 11, then the sensing spot of the one transmission unit is imaged more sharply on the receiver than that of the other transmission unit, with the difference in sharpness being ~~able to be~~

detected by the different widths of the mutually corresponding regions or peaks of the respective intensity distribution A or B. With a sensed object relatively far away from the sensor 11, it is the other way round, that is the other sensing spot is imaged more sharply.

[0051] If interfering radiation, for example due to a reflecting interfering object 15 (cf. Fig. 2a), is incident on the reception unit, then the intensity distribution C shown schematically in the lower illustration of Fig. 2b results, for example. The interference signal of the interfering object 15 can therefore have the consequence that it can no longer be assumed, on the basis of a difference in the sharpness of the imaged sensing sports corresponding to an expected amount, that the peaks can be used to determine the correct object distance.

[0052] The presence of an interfering object 15 adulterating the measurement can therefore be recognized by the detection of a received signal not showing the expected intensity curve.

[0053] The embodiment of the invention in accordance with Figs. 3a and 3b shows a further possibility of using an additional channel to eliminate the corrupting influence of an interfering object 15 adulterating the measurement of the object distance D.

[0054] The sensor 11 comprises two transmission units S1 and S2 as well as a common reception unit E. A common optical transmission system FS is provided for the two transmission units S1, S2 in the form of a lens, and an optical reception system FE is provided for the reception unit and is also formed as a lens.

[0055] Whereas the emitted sensing rays 25 are focused in the measuring channel S1-E formed by the transmission unit S1 and the reception unit E for the generation of a sensing spot on the sensed object 13, it is ensured in the additional channel S2-E that a sensing zone is emitted into the half-space of the sensor 11 on the sensed object side which is spatially substantially further expanded in comparison with the sensing rays 25 of the measuring channel S1-E. The sensing zone can be generated by deliberate non-focusing, scattering, expansion and/or diffuse transmission of the sensing rays of the transmission unit S2.

[0056] Interfering radiation which is caused, for example, by scattering in the transmission unit S2, by reflections and/or remittance at optical elements such as diaphragms or tubes and by defects in the optical transmission system FS such as scratches, dust or striae at a transmission lens, and which is reflected and/or remitted onto the reception unit E by an interfering object 15, is deliberately imaged by the sensing zone.

[0057] Fig. 3b shows the intensity distributions of the two received signals coming from the two transmission units S1, S2. A case is shown where, due to the above-mentioned error sources, radiation transmitted in the measuring channel S1-E is also incident on the interfering object 15 and is reflected and/or remitted by this onto the reception unit E, whereby an intensity peak is generated at the position X2. The corresponding intensity peak of the transmission unit S2 of the additional channel is higher than that of the measuring channel in which the operation takes place with focused sensing rays 25 as a result of the deliberate imaging of the interfering radiation. At the position X1, however, which corresponds to the object distance D to be determined, a higher received signal occurs in the measuring channel S1-E than in the additional channel S2-E, since the intensity distribution of the sensing zone at the sensed object is lower than

that of the sensing rays 25 with which a sensing spot is generated on the sensed object 13.

[0058] The joint evaluation of the received signals of the two channels takes place in that the received signal S2 of the additional channel is deducted from the received signal S1 of the measuring channel and negative difference values are set to zero. A positive difference signal then remains at the position X1 on the reception unit E corresponding to the object distance D. This resulting positive difference signal is then used for the determination of the object distance D.

[0059] In the embodiment shown, the transmission units S1, S2 and the reception unit E are arranged in the joint sensor plane 21, with the transmission unit S2 of the additional channel, by means of which the spatially expanded sensing zone is produced, being located between the transmission unit S1 of the measuring channel and the reception unit E. The imaging of the rays emitted by the two transmission units S1, S2 takes place by the joint optical transmission system FS. The intensity in the measuring channel and in the additional channel are selected such that the additional channel delivers a higher signal at the position X2 on the reception unit E corresponding to the interfering object 15 than the measuring channel, as is shown in Fig. 3b, so that a positive signal remains only at the position X1 corresponding to the object distance D in the evaluation subsequent to the formation of the difference between the two received signals.

[0060] Figs. 4a and 4b show a further embodiment of the invention which is in particularly suitable to eliminate the damage of thc interfering influence of so-called contrast edges 17 on the sensed object. Contrast edges can, for example, be transitions between dark and light surfaces in lettering

on the sensed object 13. In the schematic representation of Fig. 4a, a region with low reflection and/or remittance capability is shown in hatched form. The sensing spot 19 emitted by the sensor 11 simultaneously covers a region with high reflection and/or remittance capability and a region with low reflection/remittance capability.

[0061] The effect of the contrast edge 17 at the reception side is shown in Fig. 4b indicating the received signals at the two reception units E1, E2. The received signal is lower in the region corresponding to the sensed object surface with low reflection and/or remittance capability.

[0062] If only one reception unit and thus only one received signal were present, then adulteration would occur in the formation of the center of the intensity distribution in order to determine the object X position required for the determination of the object distance D, since this X position would be shifted in the direction of the region having a high reflection and/or remittance capability.

[0063] The additional channel is provided in accordance with the invention by means of a further reception unit E2 and delivers an additional received signal in which the contrast edge 17 also has an effect. Thus two received signals are present which each have a characteristic region deriving from the contrast edge 17 in which the intensity changes abruptly or stepwise.

[0064] In the evaluation of the intensity distributions, these characteristic regions can be identified without problem and associated with corresponding positions X1, X2 on the reception units E1, E2. Independently of the specific curve of the intensity distributions of the

received signals, the distance ΔX of the positions X1, X2 of the characteristic regions forms a measure for the object distance D to be determined.

~~Reference numeral list~~

~~11 — sensor~~

~~13 — sensed object~~

~~15 — interfering object~~

~~17 — contrast edge~~

~~19 — sensing spot or bead~~

~~21 — sensor plane~~

~~23 — sensor housing~~

~~25 — sensing rays~~

~~D — object distance~~

~~S, S1, S2 — transmission unit~~

~~E, E1, E2 — reception unit~~

~~FS, FS1, FS2 — optical transmission system~~

~~FE, FE1, FE2 — optical reception system~~

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